

U.S. Application Serial No.: 10/666,564
Amendment After Final Office Action Dated April 17, 2006
In Response to Final Office Action Dated January 17, 2006

Amendments to the Claims

This listing will replace all prior versions and listings of claims in the application:

Listing of the Claims

Please amend the claims as follows:

Claim 1. (currently amended) A closed air gap interconnect structure comprising:
 at least two conductive interconnect lines separated by an air gap and supported underneath by a plurality of regions of a robust support dielectric disposed only underneath said interconnect lines and not beneath the ~~air-gap~~, gap;
 wherein at least one of said lines is connected to at least one conducting via which is encased in said robust support ~~dielectric~~, and dielectric;
 wherein said lines are capped on top by a cap layer;
 wherein said regions of robust support dielectric form an array of pillars; and
 wherein said regions of robust support dielectric form support beams that lie below said interconnect lines and encase at least one of said conducting via.

Claim 2. (withdrawn) An interconnect structure according to Claim 1, wherein said conductive interconnect and said conductive via comprise a conductive liner and a conductive fill material.

Claims 3-4. (canceled)

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Claim 5. (withdrawn) An interconnect structure according to Claim 1, wherein said regions of robust support dielectric form a support plate that lies below said interconnect lines and encase at least one of said conducting via.

Claim 6. (withdrawn) An interconnect according to Claim 1, wherein said cap layer is a dielectric barrier comprising a regular array of holes which are closed off with same or different dielectric barrier material.

Claim 7. (currently amended) A closed air gap interconnect structure comprising:

 a substrate;

 a first sacrificial dielectric coated on said substrate, said first coated sacrificial dielectric having therein a patterned set of support regions formed by lithography and filled and planarized with a robust line support dielectric, said first sacrificial dielectric having therein contact via holes patterned by reactive ion etching;

 a second sacrificial dielectric coated on said first sacrificial dielectric and said filled and planarized support regions, said second sacrificial dielectric having lithographically patterned line trenches;

 a conductive material filled into said line trenches and said via holes and planarized; and

 a stencil with a regular array of holes on said filled line trenches and said second sacrificial dielectric;

 wherein said first and second sacrificial dielectrics have been extracted to form air gaps and said regular array of holes have been closed off by depositing a cap dielectric thereby forming said closed air gap interconnect structure;

wherein said regions of robust line support dielectric form an array of pillars; and

wherein said regions of robust line support dielectric form support beams that lie below said interconnect lines and encase at least one of said conducting via.

Claim 8. (currently amended) A closed air gap interconnect structure comprising:

a substrate;

a first sacrificial dielectric coated on said substrate, said first coated sacrificial dielectric having therein a patterned set of support regions formed by lithography and filled and planarized with a robust line support dielectric, said first sacrificial dielectric having therein contact via holes patterned by reactive ion etching;

a second sacrificial dielectric and an optional hard mask layer disposed on said second sacrificial dielectric; said second sacrificial dielectric and said hard mask having lithographically patterned line trenches;

a conductive material filled into said line trenches and said via holes and planarized such that top of the filled conductive material is substantially coplanar with the top surface of said optional hard mask;

an optional first dielectric cap layer disposed on said hard mask layer; and

a stencil with a regular array of holes on top of said cap layer, wherein said regular array of holes have been transferred into said first cap layer and said hard mask layer by a reactive ion etch process;

wherein said first and second sacrificial dielectrics have been extracted to form air gaps and a second dielectric cap has been deposited to pinch off the tops of said regular array of holes in said first cap layer thereby closing off said regular array of holes forming said closed air gap interconnect structure;

wherein said regions of robust line support dielectric form an array of pillars; and

wherein said regions of robust line support dielectric form support beams that lie below said interconnect lines and encase at least one of said conducting via.

Claim 9. (currently amended) A closed air gap interconnect structure comprising:

a substrate;

a first sacrificial dielectric coated on said substrate, said first coated sacrificial dielectric having therein a patterned set of support regions by lithography and filled and planarized with a robust line support dielectric, said first sacrificial dielectric having therein contact via holes patterned by reactive ion etching;

a second sacrificial dielectric and an optional hard mask layer disposed on said second sacrificial dielectric coated on said first sacrificial dielectric, said second sacrificial dielectric and said hard mask having lithographically patterned line trenches;

an optional thin conformal dielectric passivation liner layer deposited on said contact via holes and said line trenches;

a conductive material filled into said line trenches and said via holes and planarized such that top of the filled conductive material is substantially coplanar with the top surface of said hard mask;

an optional first dielectric cap layer disposed on said hard mask layer; and

a stencil with a regular array of holes on top of said first cap layer, wherein said regular array of holes have been transferred into said cap layer and said hard mask layer by a reactive ion etch process;

wherein said first and second sacrificial dielectrics have been extracted to form air gaps and an optional second dielectric cap has been deposited to pinch off the tops of said regular array of holes in said first cap layer thereby closing off said regular array of holes forming said closed air gap interconnect structure;

wherein said regions of robust line support dielectric form an array of pillars; and
wherein said regions of robust line support dielectric form support beams that lie
below said interconnect lines and encase at least one of said conducting via.

Claim 10. (currently amended) A closed air gap interconnect structure comprising:

- a substrate;
- a first sacrificial dielectric coated on said substrate, said first coated sacrificial dielectric having therein a patterned set of support regions by lithography and filled and planarized with a robust line support dielectric, said first sacrificial dielectric having therein contact via holes patterned by reactive ion etching;
- a second sacrificial dielectric coated on said first sacrificial dielectric and said filled and planarized support regions, said second sacrificial dielectric having lithographically patterned line trenches;
- a conductive material filled into said line trenches and said via holes and planarized;
- an optional conductive material cap disposed on top surfaces of said conductive material filled into said trenches; and
- a stencil with a regular array of holes on said line trenches and said second sacrificial dielectric and said optional conductive material cap;

wherein said first and second sacrificial dielectrics have been extracted to form air gaps and said regular array of holes have been closed off by depositing a cap dielectric thereby forming said closed air gap interconnect structure;

wherein said regions of robust line support dielectric form an array of pillars; and
wherein said regions of robust line support dielectric form support beams that lie
below said interconnect lines and encase at least one of said conducting via.

Claim 11. (currently amended) A closed air gap interconnect structure comprising:

a substrate;

a first sacrificial dielectric coated on said substrate, said first coated sacrificial dielectric having therein a patterned set of support regions by lithography and filled and planarized with a robust line support dielectric, said first sacrificial dielectric having therein contact via holes patterned by reactive ion etching;

a second sacrificial dielectric and an optional hard mask layer disposed on said second sacrificial dielectric coated on said first sacrificial dielectric, said second sacrificial dielectric and said hard mask having lithographically patterned line trenches;

a conductive material filled into said line trenches and said via holes and planarized such that top of the filled conductive material is substantially coplanar with the top surface of said hard mask;

an optional conductive material cap disposed on top surfaces of said conductive material filled into said trenches;

an optional first dielectric cap layer disposed on said hard mask layer and said conductive material cap; and

a stencil with a regular array of holes on top of said first dielectric cap layer, wherein said regular array of holes have been transferred into said first dielectric layer and said hard mask layer by a reactive ion etch process;

wherein said first and second sacrificial dielectrics have been extracted to form air gaps and a second dielectric cap has been deposited to pinch off the tops of said regular array of holes in said first cap layer thereby closing off said regular array of holes forming said closed air gap interconnect structure;

wherein said regions of robust line support dielectric form an array of pillars; and

wherein said regions of robust line support dielectric form support beams that lie below said interconnect lines and encase at least one of said conducting via.

Claim 12. (currently amended) A closed air gap interconnect structure comprising:

a substrate;

a first sacrificial dielectric coated on said substrate, said first coated sacrificial dielectric having therein a patterned set of support regions by lithography and filled and planarized with a robust line support dielectric, said first sacrificial dielectric having therein contact via holes patterned by reactive ion etching;

a second sacrificial dielectric and an optional hard mask layer disposed on said second sacrificial dielectric coated on said first sacrificial dielectric, said second sacrificial dielectric and said hard mask having lithographically patterned line trenches;

a thin conformal dielectric passivation liner layer deposited on said contact via holes and said line trenches;

a conductive material filled into said line trenches and said via holes and planarized such that top of the filled conductive material is substantially coplanar with the top surface of said hard mask; and an optional conductive material cap disposed on top surfaces of said conductive material filled into said trenches;

an optional first dielectric cap layer disposed on said hard mask layer and said conductive material cap; and

a stencil with a regular array of holes disposed on top of said first dielectric cap layer, wherein said regular array of holes have been transferred into said first dielectric layer and said hard mask layer by a reactive ion etch process;

wherein said first and second sacrificial dielectrics have been extracted to form air gaps and a second dielectric cap has been deposited to pinch off the tops of said

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regular array of holes in said first cap layer thereby closing off said regular array of holes forming said closed air gap interconnect structure;

wherein said regions of robust line support dielectric form an array of pillars; and
wherein said regions of robust line support dielectric form support beams that lie below said interconnect lines and encase at least one of said conducting via.

Claims 13-33. (canceled)